OBSERVATION OF 17 GHz RADIO EMISSION FROM X-RAY BRIGHT POINTS

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Abstract

Using observations made with the Nobeyama radio heliograph (NRH) at 17 GHz and the Yohkoh/SXT experiment, we report the first detection of 17 GHz signatures of coronal X-ray bright points (XBP's). This is also the first reported detection of flaring bright points in microwaves. We have dectected four BP's at 17 GHz out of eight observed by SXT on July 31, 1992, for which we looked for 17 GHz emission. For one XBP located in a quiet mixed-polarity-region, the peak times at 17 GHz and X-rays are very similar, and both are long lasting – at least 6 hours in duration. There is a second BP (located near an active region) which is most likely flaring also, but the time profiles in the two spectral domains are not similar. The other two 17 GHz BPs are quiescent with fluctuations superposed upon them. For the quiet region XBP, we believe that the 17 GHz emission is thermal.

1. Introduction

Solar X-ray bright points (XBP's) are compact emitting regions associated with bipolar magnetic fields. Their properties as deduced from Skylab observations have been discussed by Golub et al. (1974, 1977). At any one time there appear to be dozens of XBPs present on the Sun. Their lifetimes range from a few hours to several days, although only a small number appear to last over two days. They are known to flare. The Japanese solar satellite Yohkoh, carrying a soft X-ray telescope of unprecedented resolution now provides excellent images of X-ray bright points with high time resolution on a regular basis (Nitta et al. 1992; Strong et al. 1992), and joint studies of XBPs with observations at other wavelengths are timely.

In the past, coronal bright points have been studied in microwaves. Using the VLA, Habbal et al. (1986) and Fu et al. (1987) produced the first maps of coronal bright points at 20 cm and 6 cm wavelengths, respectively, and demonstrated that they were similar in behavior to those seen in soft X-ray and EUV wavelengths. Kundu et al. (1988) using the

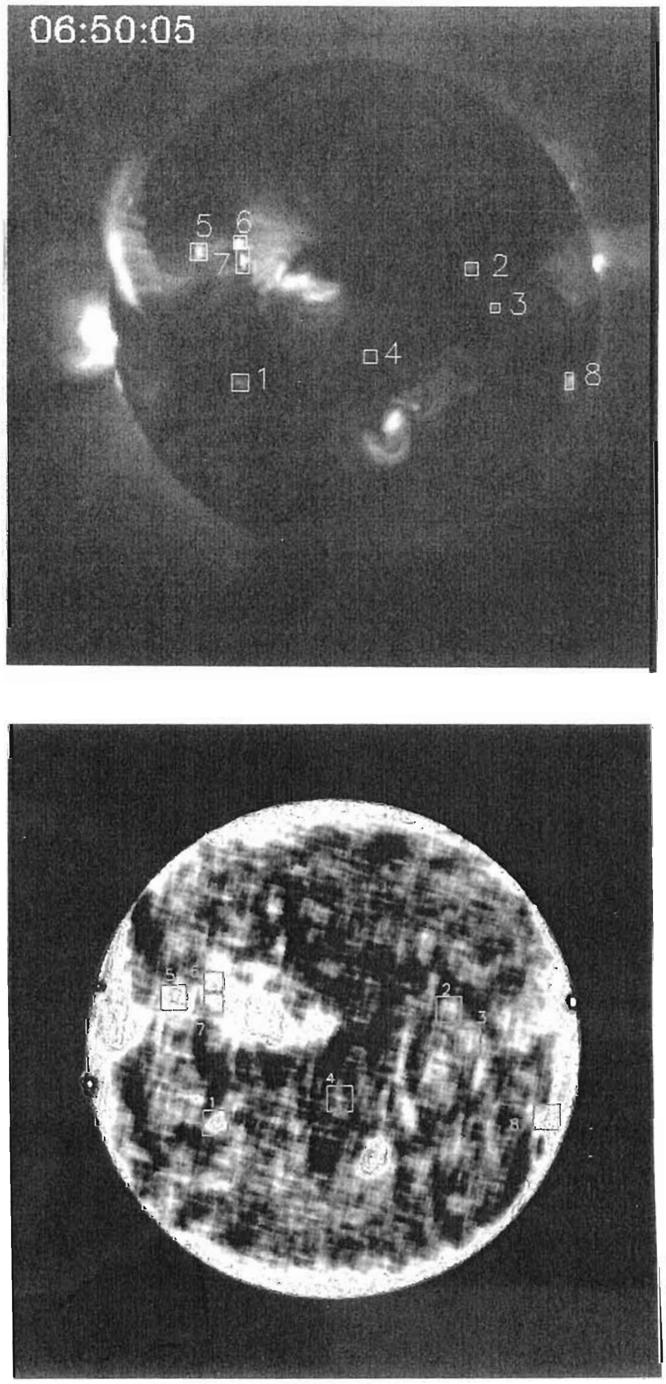

Fig. 1. A full disk Yohkoh/SXT image of the Sun for July 31, 1992 (top), showing the locations of eight X-ray bright points studied in this paper. Also shown is the full disk 17 GHz image at 0330 UT when the BP1 is the brightest (bottom).

VLA in C-configuration produced maps of coronal bright points nearly simultaneously at 6 and 20 cm wavelengths. According to Kundu et al. (1988), both 6 and 20 cm emissions from bright points are consistent with optically thin free-free emission. Indeed, using the differential emission measure for a 10^5 K to 10^7 K plasma known to exist for active regions, one can calculate the emission at 20 cm. One finds that a reasonable flux of microwave emission can arise from a region with temperature of (1-2) $\times$ 10^6 K. In this paper, we report the detection of 17 GHz radio emission from flaring X-ray bright points. We take advantage of the improved sensitivity in soft X-rays available with the Yohkoh/ SXT telescope (Ogawara et al. 1991; Tsuneta et al. 1991) and the excellent accuracy of source location and sensitivity available with the Nobeyama Radioheliograph in Japan (Nakajima et al. 1993).

2. Observations

The radio observations at 17 GHz were made with the Nobeyama Radio Heliograph (NRH) with a spatial resolution of 10" arc and a temporal resolution of 1 second. It has a field of view of 40' min covering the entire Sun, a dynamic range of better than 20 db, and in the snapshot mode (1 second) it has a sensitivity of 10 msfu. On July 31, 1992, on the Yohkoh/SXT images there existed quite a few XBP's, some of whom flared up. On careful examination of the NRH disk images we observed several compact structures which corresponded in position to the XBP's observed by SXT. Indeed, we found that four of the eight XBP's observed clearly by SXT at any one time had radio signatures at 17 GHz. We emphasize that these are not the only eight XBP's observed by SXT but these are the ones for which we looked for 17 GHz emission on July 31, 1992. This paper is concerned with the study of these four XBP's.

3. X-ray and Radio Observations

On July 31, 1992, eight XBP's were observed on Yohkoh/SXT images. Three of these were located near the prominent active region in the N-E. The remaining five were located in quiet regions of mixed polarity as evidenced by KPNO magnetograms and the 10830 Åspectroheliogram (Fig. 1). Of the latter, the flaring XBP in the S-E quiet region (#1) is our main target of study because it was one of the two most intense and its flaring emission continued for several hours. The other intense XBP was the XBP # 5 located near the N-E AR; it also produced good radio signatures at 17 GHz. The time profile of the XBP #1 associated with 17 GHz emission is shown in Fig. 2. XBP's #2 and #3 also produced 17 GHz radio emissions, but these were weaker than the previous two. A full disk 17 GHz map at 0330 UT showing the four BP's is shown in Fig. 1. For BP #1, the peaking time at 17 GHz corresponds quite well with the x-ray peak (see Fig. 2). The BP #5, located near the N-E active region has a time profile at 17 GHz which shows some fluctuations; it is also quite intense, being 4000 K above the quiet sun level. The remaining two BP's at 17 GHz also show fluctuations, and they are weaker in intensity. We note that these time profiles are made from 1 second maps at intervals of every 15 minutes. We have produced similar time profiles from one-second data every 30 minutes and 60 minutes. The peak time for BP # 1 remains the same in all cases. Of course, the fluctuations in other BP's are smoothed out.

4. Discussion

We have detected 17 GHz radio emission from 4 flaring XBP's. Three of these (Nos. 1, 2, & 3) are located in apparent coronal holes, or rather, quiet regions of mixed polarity. The remaining BP (# 5) is situated near an active region. This is the first detection of radio emission from an XBP at the high frequency of 17 GHz reported so far; this is also the first reported detection of radio emission from a flaring XBP at any microwave frequency. We have computed several physical parameters – Te, Em and Ne from a pair of Yohkoh/SXT images

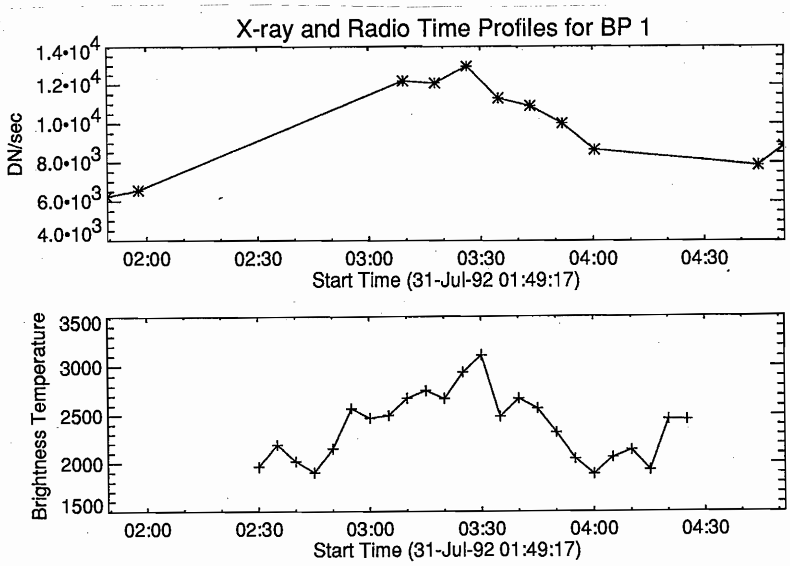

Fig. 2. Time profiles (Intensity vs. Time) of XBP #1 as observed by SXT (upper) and by NRH (lower).

in the two thinnest filters at 08:13:31 and 08:15:19 UT, approximately 5 hours after the peak of the flaring events (0330 UT). Using these X-ray parameters we have calculated the thermal emission at 17 GHz. The observed fluxes were calculated from the 1 second maps with a source size of 20 x 20 pixels (1 pixel = 4"9 arc). The observed values are higher than the calculated ones.

Acknowledgements: This research at the University of Maryland was supported by NSF grant ATM 90-19893 and NASA grant NAG W-1541. M. R. Kundu wishes to thank the staff of NRO, in particular S. Enome for hospitality and other help during his visit to NRO.

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